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September 1981
NSRP 0008

# THE NATIONAL SHIPBUILDING RESEARCH PROGRAM

## Proceedings of the REAPS Technical Symposium

## Paper No. 6: The Implementation of Production Engineering Techniques at Norfolk Shipbuilding and Drydock Corporation

U.S. DEPARTMENT OF THE NAVY
CARDEROCK DIVISION,
NAVAL SURFACE WARFARE CENTER

# Report Documentation Page

*Form Approved*
*OMB No. 0704-0188*

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| 1. REPORT DATE | 2. REPORT TYPE | 3. DATES COVERED |
|---|---|---|
| **SEP 1981** | **N/A** | **-** |

| 4. TITLE AND SUBTITLE | |
|---|---|
| **The National Shipbuilding Research Program Proceedings of the IREAPS Technical Symposium Paper No. 6: The Implementation of Production Engineering Techniques at Norfolk Shipbuilding and Drydock Corporation** | 5a. CONTRACT NUMBER |
| | 5b. GRANT NUMBER |
| | 5c. PROGRAM ELEMENT NUMBER |
| 6. AUTHOR(S) | 5d. PROJECT NUMBER |
| | 5e. TASK NUMBER |
| | 5f. WORK UNIT NUMBER |
| 7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) **Naval Surface Warfare Center CD Code 2230 - Design Integration Tools Building 192 Room 128 9500 MacArthur Blvd Bethesda, MD 20817-5700** | 8. PERFORMING ORGANIZATION REPORT NUMBER |
| 9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) | 10. SPONSOR/MONITOR'S ACRONYM(S) |
| | 11. SPONSOR/MONITOR'S REPORT NUMBER(S) |

12. DISTRIBUTION/AVAILABILITY STATEMENT
**Approved for public release, distribution unlimited**

13. SUPPLEMENTARY NOTES

14. ABSTRACT

15. SUBJECT TERMS

| 16. SECURITY CLASSIFICATION OF: | | | 17. LIMITATION OF ABSTRACT | 18. NUMBER OF PAGES | 19a. NAME OF RESPONSIBLE PERSON |
|---|---|---|---|---|---|
| a. REPORT **unclassified** | b. ABSTRACT **unclassified** | c. THIS PAGE **unclassified** | **SAR** | **26** | |

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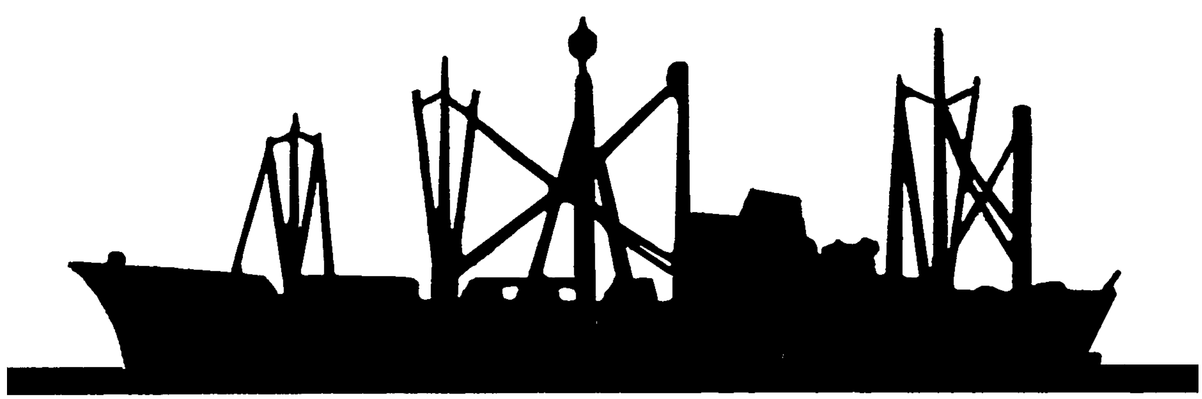
# Proceedings
# IREAPS Technical Symposium

September 15-17, 1981

Baltimore, Maryland



INSTITUTE FOR RESEARCH AND ENGINEERING FOR AUTOMATION AND PRODUCTIVITY IN SHIPBUILDING

# IREAPS

# THE IMPLEMENTATION OF PRODUCTION ENGINEERING TECHNIQUES AT NORFOLK SHIPBUILDING AND DRYDOCK CORPORATION

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ABSTRACT

Norfolk Shipbuilding and Drydock Corporation was about to start production of a floating dock to their own account. Design drawings were obtained from a naval architectural consultant. Norshipco was aware that the information on the design drawings had to be transferred to working drawings and, where possible, the producibility of the structure improved. The paper describes how this task was carried out, the drawing formats used, and the structural and outfit changes made.

## 1: INTRODUCTION

Norfolk Shipbuilding and Drydock Corporation (Norshipco) is a medium sized shipyard occupying some 180 acres, with a total workforce of approximately 3,500.

Whilst primarily a very successful and modern repair facility, new construction of small, specialized vessels has been undertaken over several years. With the success of the repair and overhaul activities any new construction work was, for the most part, an extension of repair techniques. This was reflected in planning methods and information generated for production.

While of excellent quality and workmanship, new construction contracts of late were not as financially successful as the company had anticipated and it was decided that if *new* construction was to remain part of the company activity a way had to be found which improved performance, reduced costs and delivered completed work on time. The most likely areas where this could be achieved was firstly production methods and secondly production information which was linked to the methods agreed.

## 2: THE TEST CASE

Late in 1980, the new construction group of Norshipco was faced with the task of constructing a 200 ft. steel floating drydock to its own account. The design had been previously contracted to an independent marine consultant and budget figures for material and manhour costs were prepared and submitted to management for approval.

Upon authorization, work was started on the drydock in January 1981, using the design information received from the consultant for production purposes. The new construction group realized that if a greater financial success was to be achieved changes were necessary both in the presentation of technical information and in production methods, but were unsure as to the approach and direction to take.

At this time, the UK based company, A & P Appledore Limited, *were* conducting a facility development study and it was suggested that one of thier ship production engineers could assist in developing and establishing production methods-and technical information. This-offer was accepted and in mid February 1981 the implementation of Production Engineering techniques in new construction was started.

## 3: SCOPE OF WORK

With the drydock as a test case, the aim was to take the existing drydock design and engineer its construction to give the most efficient use of manpower, equipment and material within the existing facilities, the objective being an increase in productivity and a reduction in costs.

## 4: REVIEW OF CURRENT PRACTICES

Before the problems could be solved, they had first to be identified and possible areas for improvement found by:

a) Revieting the production processes currently being employed

b) Reviewing the nature and format of technical information being used by production

### a) Production Prosesses

These were examined on an informal basis by spending time talking to all the various levels of personnel involved and by observing established prastices. Prom this a number of things became apparent.

1) The detailed coordination of work between trades was not considered, resulting in additional manhours and material being used for rework, such as structure being removed or changed at the berth during outfitting.

2) A lack of faith in the accuracy of technical information resulted in an excess of "green" material requiring double cutting, usually at the berth,

3) While an erection sequense bad been established in the early stages of the contract the detailed assembly process had not been defined. This resulted in access difficulty and difficulty in maintaining dimensional control, both involving wasted manhours and materials.

41 The lack of staged dimensional control checks throughout the production sequence resulted in an assumulation of errors requiring corrective rework in erection.

### b) Technical Information

The initial study of the design drawings revealed why problems were being encountered in production, whilst the design drawings ensured the structural integrity and operational efficiency of the drydock, they did not consider actual producibility, In addition, the drawings themselves had a number of shortcomings.

1) The level of detail of information contained on drawings varied. In some Cases, they were over detailed to the point of chaos, in

other cases they were outline diagrams only.

2) Information was inconsistent from drawing to drawing. For example, sea chests shown on the structural drawing were shown in different locations on the piping drawing.

Two other factors also became apparent:

The use of design system diagrams for material allocation and ordering resulted in excesses of material.

The lack of a detailed material coding system resulted in large quantities of scrap material and in some cases incorrect allocation.

During this review phase, it was confirmed that the problem of using general design drawings in production and allowing individual trades to overcome their particular problems as they arose was a significant contribution to the amount of rework, trade interference and change orders encountered.

## 5: <u>APPROACH</u>

From the reviews of the Production Processes and Technical Information, it was apparent that the majority of the problems being encountered could be attributed to two major causes:

*1)* The application of repair production techniques to new construction

2) The use of basic design drawings for production purposes

By applying production engineering techniques to both the production methods and by matching the production information, to the methods, difficulties in access, fit up, assembly, trade interference and coordination, etc. could be solved before actual work started. The approach was in two stages:

a) The production engineering of the basic design.

*b)* The development of a production orientated drawing system which would align with production methods.

### *a)* <u>Production Engineering - Basic Design</u>

This involved a detailed study of the design drawings from a producibility point of view. Consideration was given to:

- existing facility capability
- work breakdown structure
- natural work orientation
- assembly and block relationships
- accessibility
- standardisation and rationalisation of piece parts and materials
- advanced outfitting of steel structure
- working practices

Figures 1 and 2 show sections from the steel structure and ballast system design drawings, indicating areas where unnecessary or difficult work would have occurred if production had followed the design drawings.

Figures 3 and 4 show the same areas engineered to overcome the difficulties. This was incorporated into the general arrangement drawings, which is the second level of drawing.

Figure 5 shows what had been the intended erection sequence and breakdown together with the associated difficulties. Figure 6 shows the modified erection sequence and breakdown which overcame the difficulties.

## *b)* Production Orientated Drawings

Having prepared the block breakdown, General Arrangement and Composite Drawings incorporating the changes, brought about by applying Production Engineering principles, we further studied the step by step assembly, outfitting and erection of the dock. The system used for transferring this thought process from the Production Engineering Section to the rest of the yard was through using a Production Orientated Drawing System.

Figure 7 shows the first stage of this sytem. Dividing the dock into Structure Groups and then into blocks in the Block Breakdown, each block was further analyzed in a structure group and like assemblies identified to form the Block Assembly Analysis. From the Block Assembly Analysis further study into the most convenient process of block assembly, integrated pre-outfitting, lifting and turning operations provided the Block Process Engineering, Figure 8. At this point in time, the drawings that have been produced are purely a method of transferring the thoughts of how the Production Engineer has arranged the structure in the General Arrangement drawings for ease of assembly.

From the Production Engineering drawings, the detail drawing office then prepared work stage drawings. Each drawing reflects exactly the work to be done at each stage of the assembly process, together with information for checking the dimensional accuracy. Drawings are produced for each differenct assembly in the orientation to be used on the shop floor. The method in which the drawings are issued to production can therefore be used to control the production process. For example, using a batch production process all like assemblies, say stiffened panels, belonging to the same structure group may be required to be produced consecutively, By issuing only the Panel

Assembly drawings, the production shops only have sufficient information to produce panels. This control prevents any unauthorised intervention in the production schedule. By parallel development of steel and outfit drawings in this manner the maximum benefit of advanced outfitting can be achieved. In this way, work package information was used to schedule production processes.

For piece part generation, standard sheet formats were developed for each individual machine and operation containing only the information required to produce the parts and set up the machine.

To enable the system to,function effectively, a coding system was developed to reflect the assembly process, i.e. piece part coding, assembly coding and block coding. Figures 9 to 15 show photographs of the actual parts and assemblies produced and the information format provided to the shop floor. The benefits from the implementation of this system are:

- a reduction in labour manhours by eliminating misinterpretation of drawings
- a reduction in material cost by providing an accurate material ordering and allocation coding system
- the elimination of rework due to trade interfaces
- improved dimensional control
- an easy and reliable planning and scheduling system identifiable with production processes
- the basis for recording performance and creating more accurate estimating data

## 6: EFFECT IN TEE TECHNICAL OFFICE

Because design drawings were used by production and additional requirements were largely subcontracted, the permanent drawing office staff at Norshipco was small and only consisted of three draftspersons, controlled by a contract supervisor.

At the beginning of the implementation program, one draftsman was appointed to work with the A & P Appledore Engineer, organizing the technical information for the drydock. In the initial stages of the program, with production of the drydock in progress and limited technical staff available, it became obvious that if the implementation of production.engineering techniques was to be successful either an increase in technical staff or a slowing of production was necessary. Realising this, the management decided that an increase in staff was unacceptable and production was slowed for four weeks to allow the technical information format to be developed. This was a bold decision to make and demonstrates the commitment of senior management which is so important to the success of such a project. When production resumed normal working, the technical information format and approach had been agreed and the major general arrangement drawings incorporating production engineering principles were complete.

A progressive restructuring of the technical section took place over the following months. Two members of staff were recruited from other sections of the technical office to form the Production Engineering Section. This small group controls the program and the development and issue of technical information to production. As other drawing office staff became available, they were transferred to the drydock project. At the end of May 1981, a total of four permanent staff were engaged on the drydock project.

The limited period given to the implementation program did not allow any formal training of technical staff or explanatory talks *to* production. Through a series of structured but informal discussions and on the job training, the technical staff became aware of the requirements of the technical system. Similarly, discussions with the various levels of production and management personnel allowed the system to develop to provide the required information for all departments.

The practice of subcontracting any additional drawing requirements from the design information made the assessment of increased drafting manhours difficult. However, the implementation of a similar system in a already efficient European shipyard did show an increase of 15% over traditional drawing practices, with a corresponding 10% reduction in production manhours.

The implementation of this type of technical system does require an increase in lead time before production start but the reduction in production time achieved does give a reduction in the overall contract time, employing similar manning levels.

## 7: EFFECT IN PRODUCTION

The drydock is the first yard project at Norshipco to use this sytem. At this time, the drydock is approximately 40% complete. The labor cost and figures to date are extremely satisfactory. Direct benefits due to the implementation of production engineering techniques proposed by A & P Appledore are now being realised by Norshipco in terms of reductions in both labor manhours and materials costs while maintaining the production program.

Labor manhour usage is currently running at about 50% of the original estimate for the dock construction. It is expected that at the completion of the contract the total manhour budget will be less than 70% of the original estimate, a reduction of 30% in production manhours. The reduction in production manhours can be directly attributed to the implementation of production engineering and production orientated drawings. There has been a significant reduction in trade interfaces and rework. The attitudes of the labor force have been much more positive, as they are mow furnished with clears concis information which relieves them from the task of drawing interpretation.

while a substantial reduction in productiom manhours was expected, a reduction in direct material costs came as a pleasant surprise. The parallel development of a detailed stage by stage coding system providing precise identificaton for ordering and allocation of material reduced the amount of waste dramatically compared with previous contracts

Other: substantial material savings were made during the initial stages 0% production engineering, FOP example, by considering structure and piping as a whole reduced the amount of ballast main piping required in the bottom structure alone by over 100 ft., a saving in material costs 0f $10,000,

Nora and more benefits are being realfsed due to the implementation 0f this type 0f technical approach. The benefits are mot always as direct as labor and material saving but a more reliable scheduling system increasses the confidence of forecasting at the corporate level, Coding, standisation and rationalisation facilitate batch ordering and storage systems allowing a more efficient use of space, identifyimg the construction sequence allows a more efficient use of service trade5 such as cranes, riggers, etc, assuring better control and reduction of overhead costs

Another long term benefit is the accumulatfon of an accurate data *base* for estimating. By including weight and joint length information on the production drawings, records are being kept regarding manhours spent on assembly types, Together with the machine operatiom formats and production data a solid base is being built up for future contract estimating directly related to the actual performance and limitations of the existing facility.

The origbnal estimate for the cost of the drydock *was submitted on the* basis of past performance in new construction, At this time, approximately 7 months from the start 0f the implementation of production engineering techniques the total cost of eke drydock will be approximately 20% lower tban the original estimated cost without any capital investment in new equipment or additional labor.

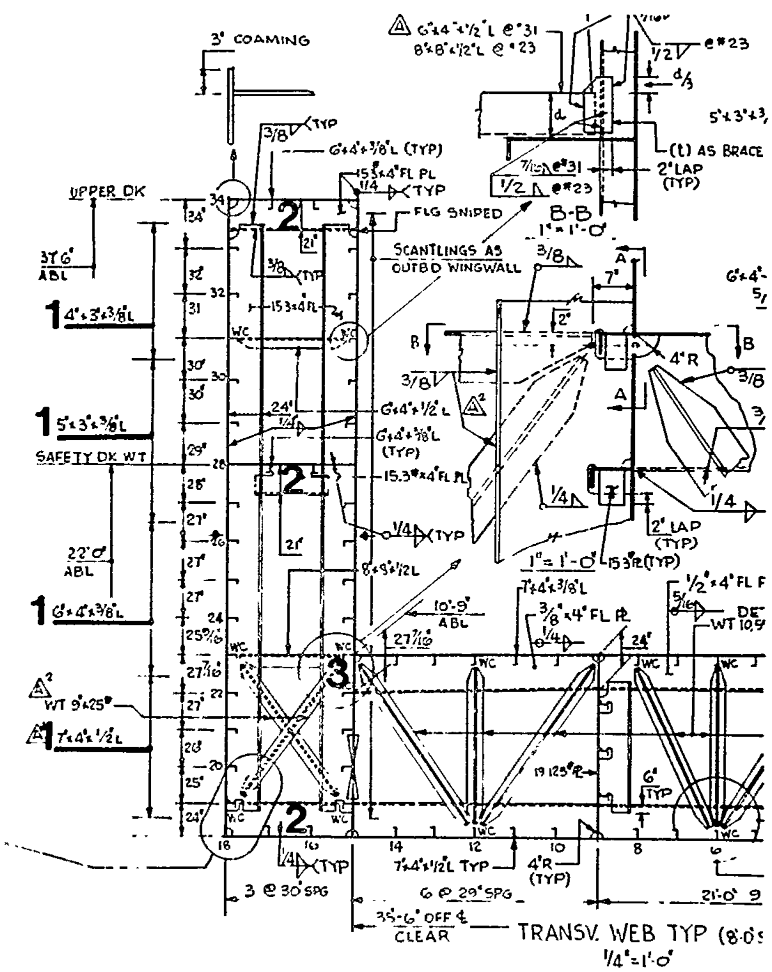
we feel that the implementaiton 0f this system in new construction is proving to be successful *enough* to warrant its current expansion in to the field of naval and commerical repair,

The conclusion that can be drawn from this practical example is that the implementation of Production engineering techniques, improved production methods and a technical information system aligned to the needs of production increases the requirement for technical expertise. However, if this is we11 managed and directed, a significant reduction in production time and costs can be achieved along with am improvement in quality of workship and increased job satisfaction to all concerned.

1 Non Rationalisation of Stiffener Scantlings

3 Misalignment of Moulded Line due to Lap Construction

2 Non Standardisation of Piece Parts



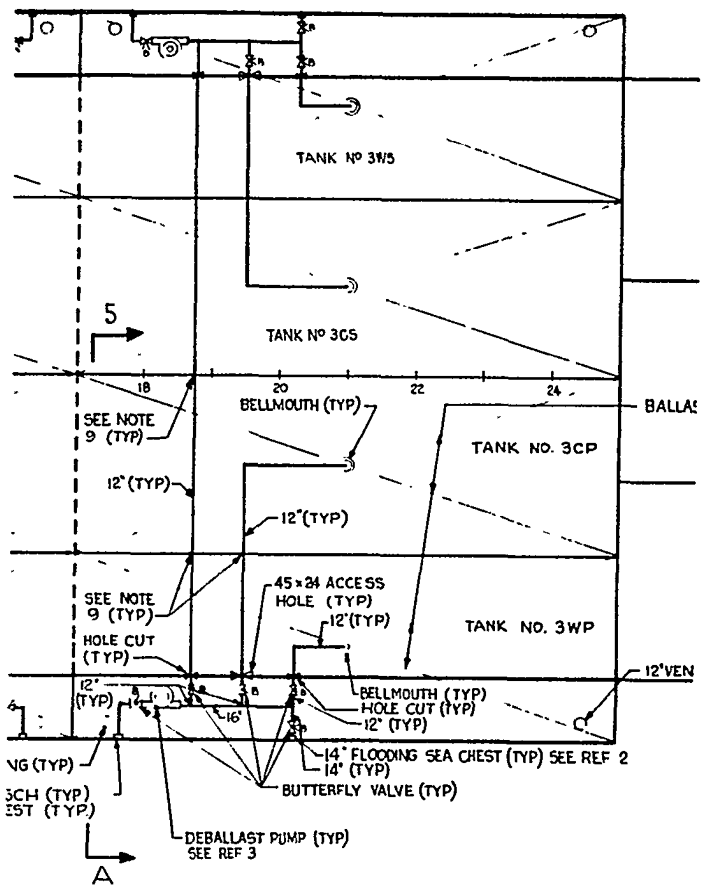

PART PLAN OF STRUCTURAL DESIGN

FIGURE 1

1. Disregard of Structure

2. Excess Material in Pipe Routing

3. No Modulisation or Pre-Outfitting Considerations



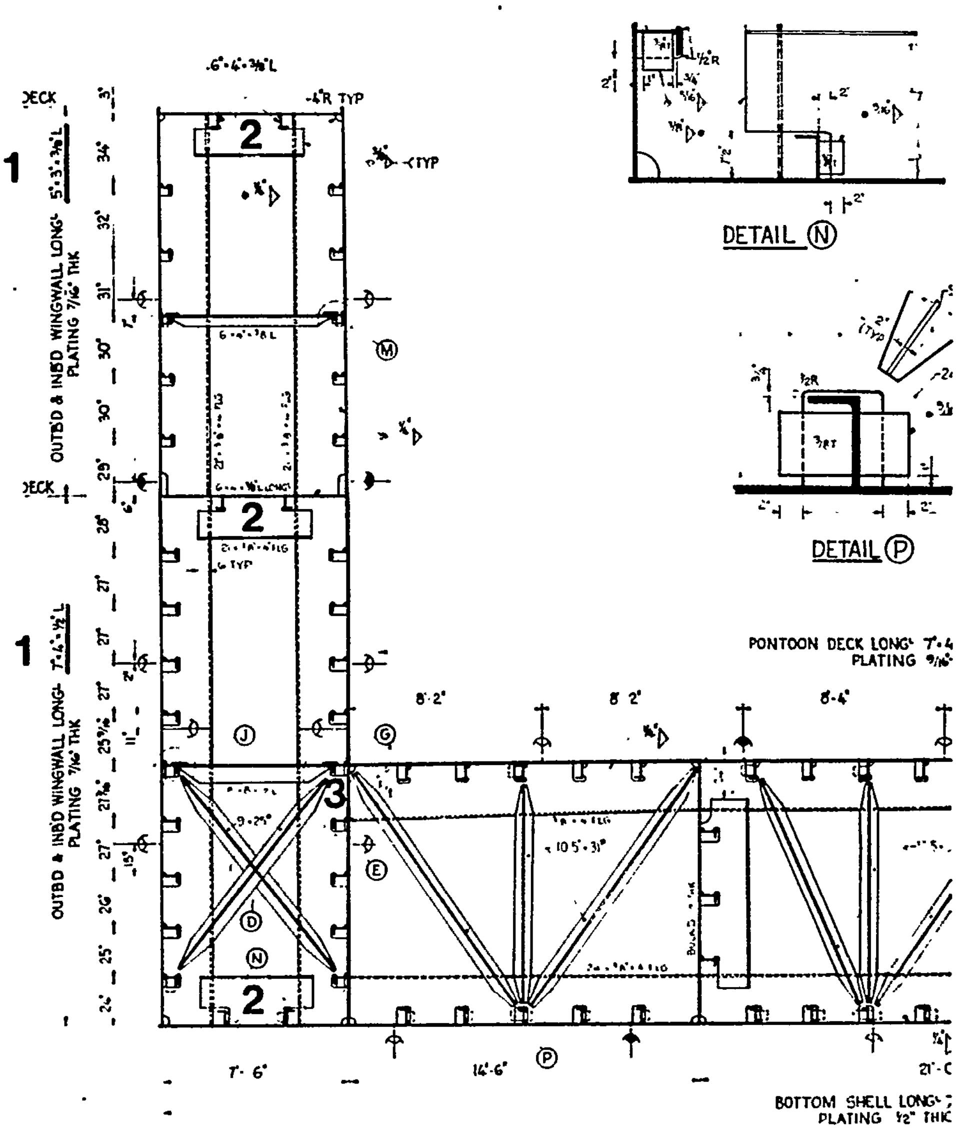

PART PLAN OF
BALLAST SYSTEM DESIGN

FIGURE 2

1. Rationalisation of Stiffener Scantlings

2. Standardisation of Piece Parts

3. Change in Lap Construction to Provide Continuity of Moulded Line



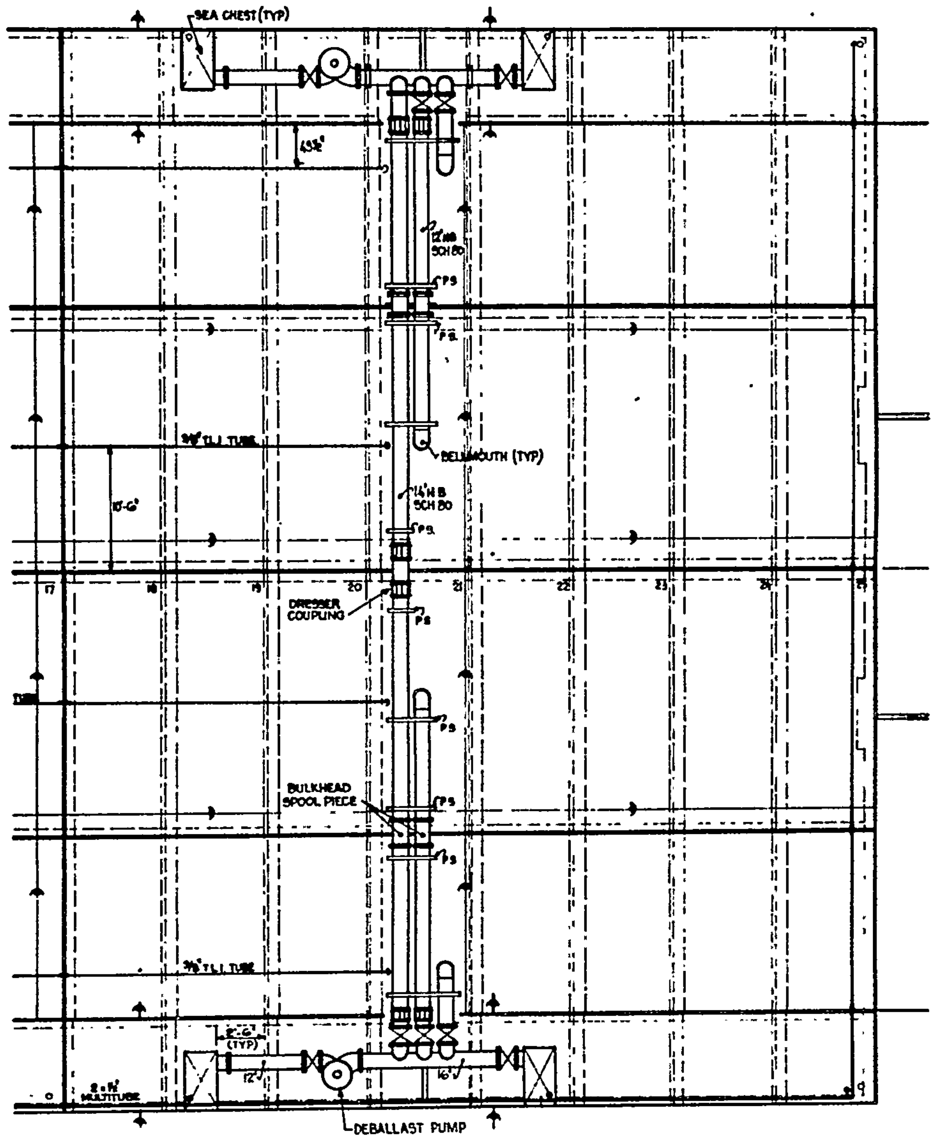

PART PLAN OF
STRUCTURAL ARRANGEMENT AFTER
PRODUCTION ENGINEERING

FIGURE 3

1. Consideration given to Structure Arrangement and Block Breakdown

2. Elimination of Excess Material by change in Pipe Routing and Arrangement

3. Pipe Arrangement changed to allow Modulisation and Pre-Outfitting

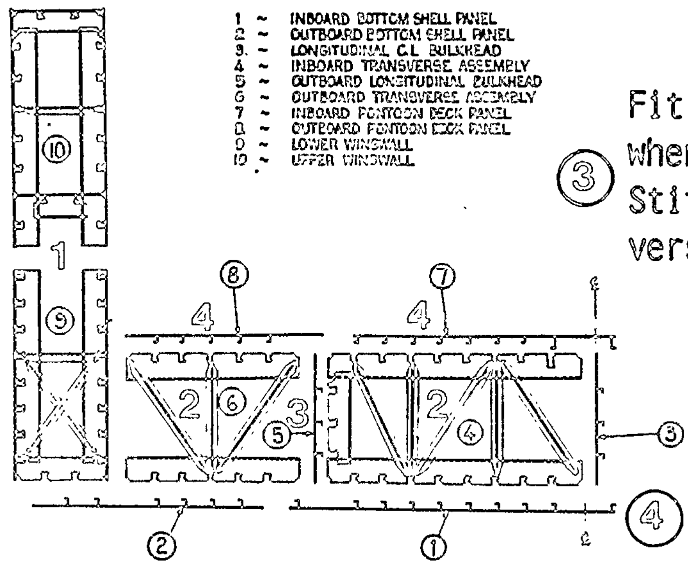



PART PLAN OF COMPOSITE ARRANGEMENT AFTER PRODUCTION ENGINEERING

FIGURE 4

Unnecessary Staging
1 Requirements and Fairing Difficulties

2 Panel Erection makes Dimensional Control Difficult




3 Fit up Problems occur when slotting Bulkhead Stiffeners into Transverse Webs

4 Excess of Overhead Welding

ORIGINAL BERTH ERECTION SEQUENCE

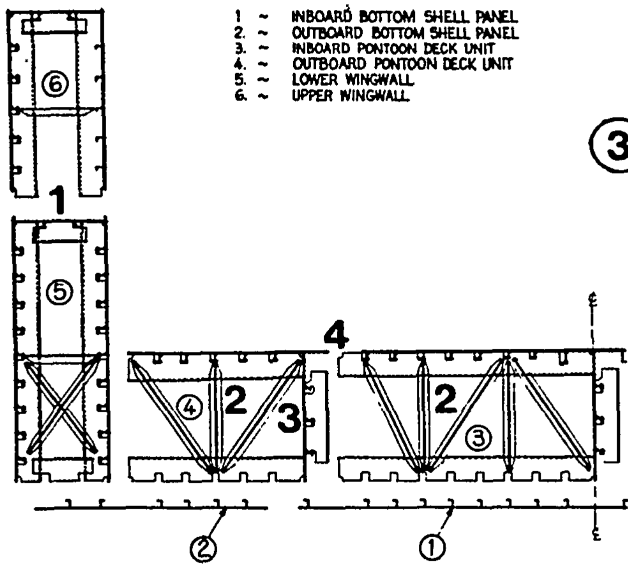
FIGURE 5

1

Self Supporting Block Reducing Staging Requirements

2

3 Dimensional Block Assembly provides greater Dimensional Control




3 Rearrangement of Bulkhead and Transverse Assemblies Eliminates Fit Up Problem

4 Overhead Welding Minimised

NEW BERTH ERECTION SEQUENCE

FIGURE 6

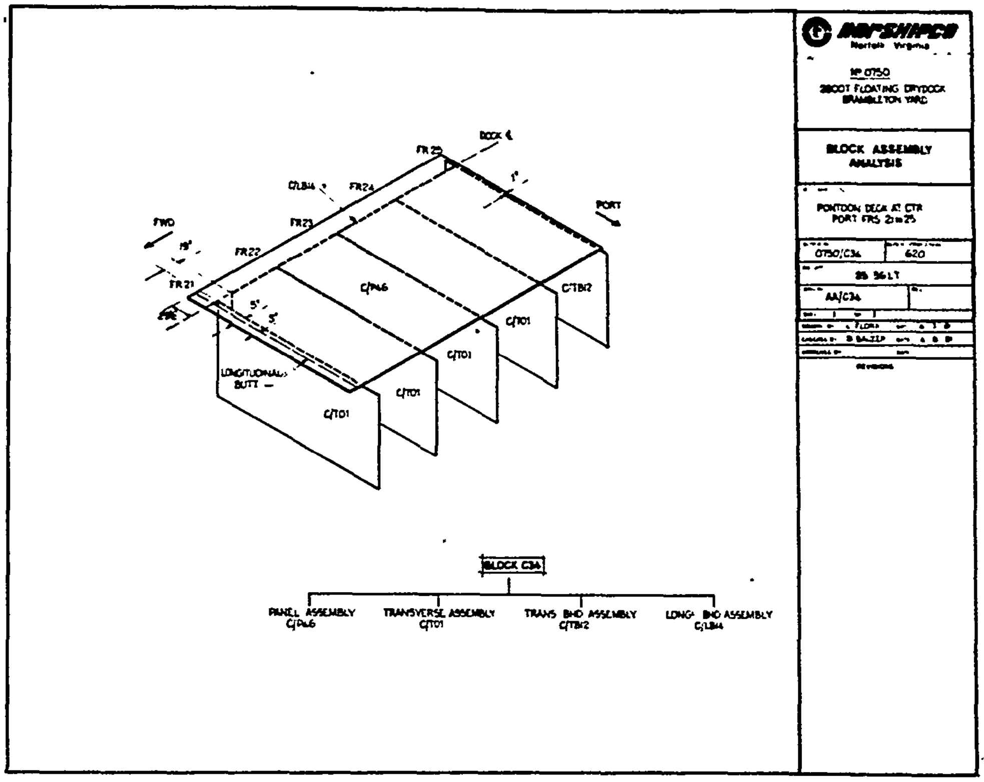


FIGURE 7 BLOCK ASSEMBLY ANALYSIS

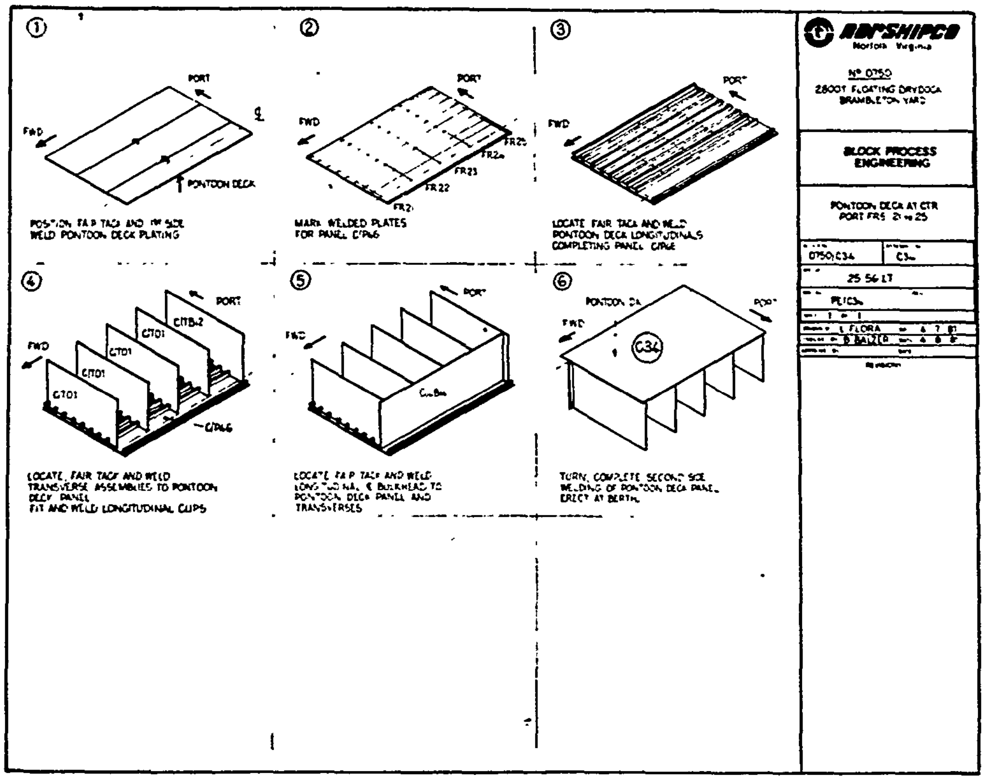
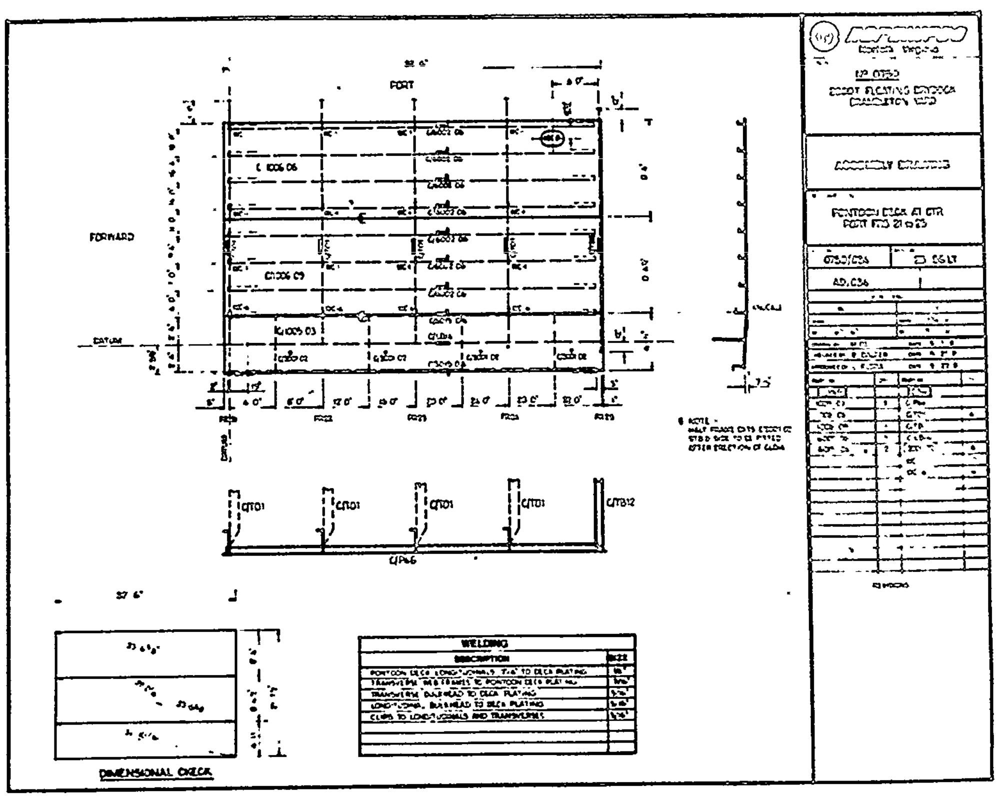
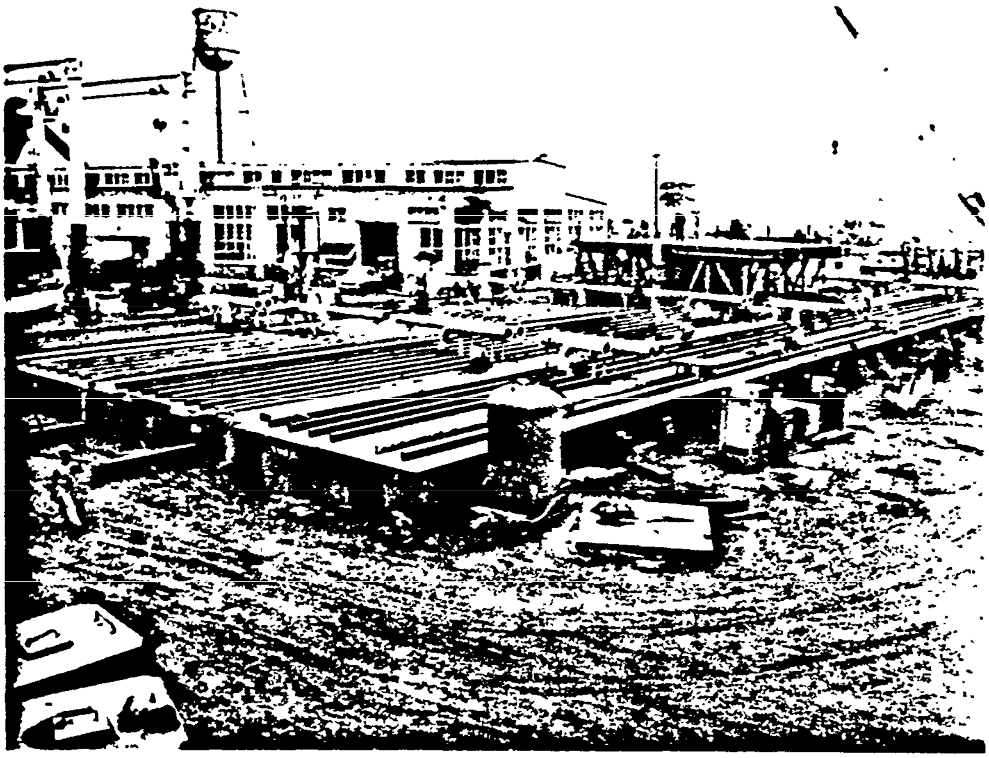


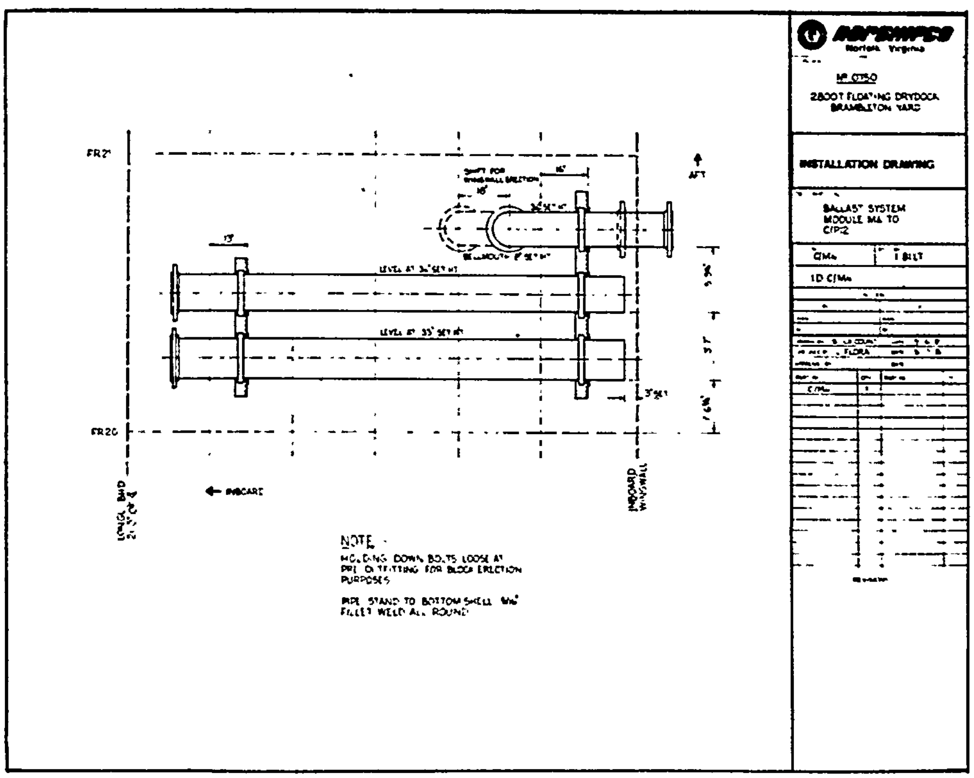
FIGURE 8 BLOCK PROCESS ENGINEERING



PANEL AND BLOCK ASSEMBLY
STAGE DRAWING

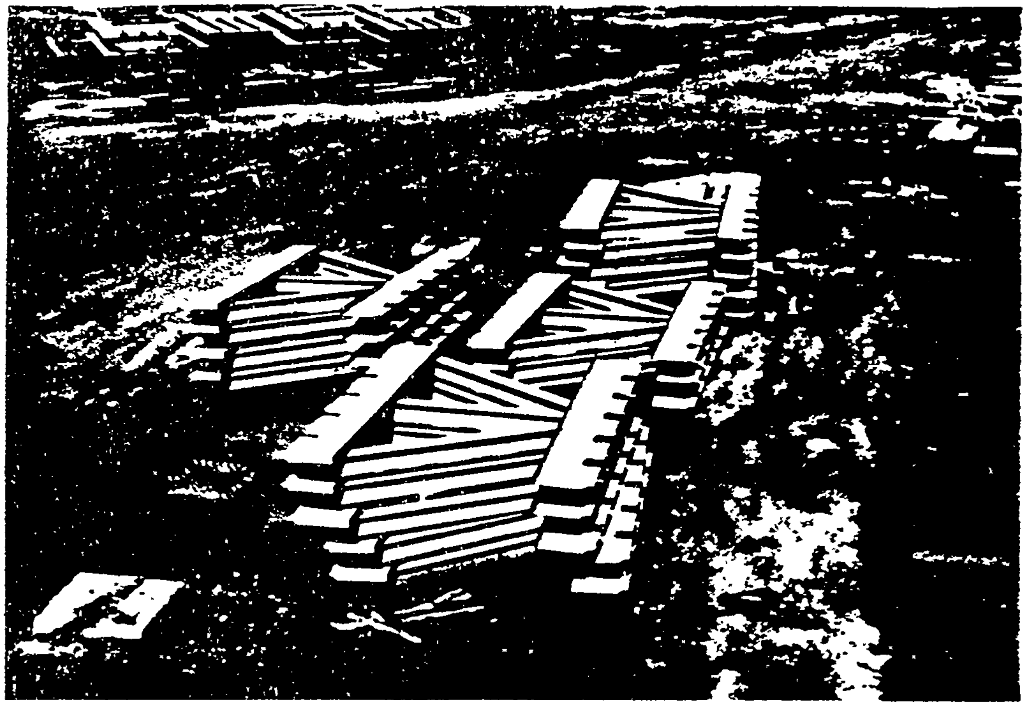
FIGURE 9

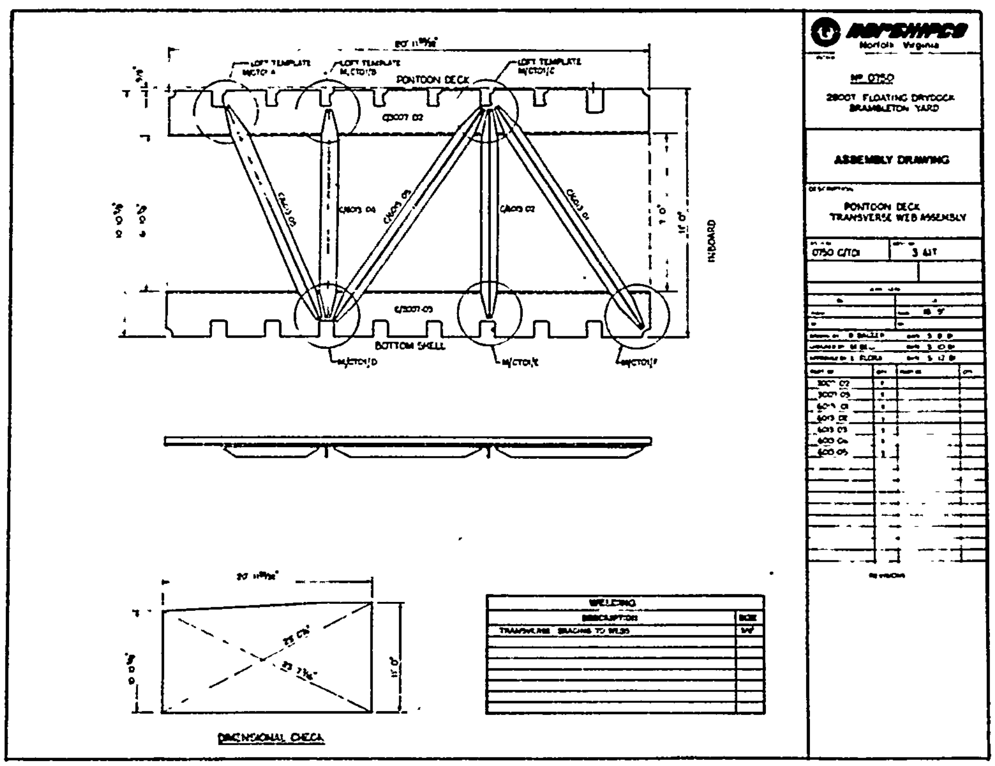





PIPE MODULE INSTALLATION DRAWING

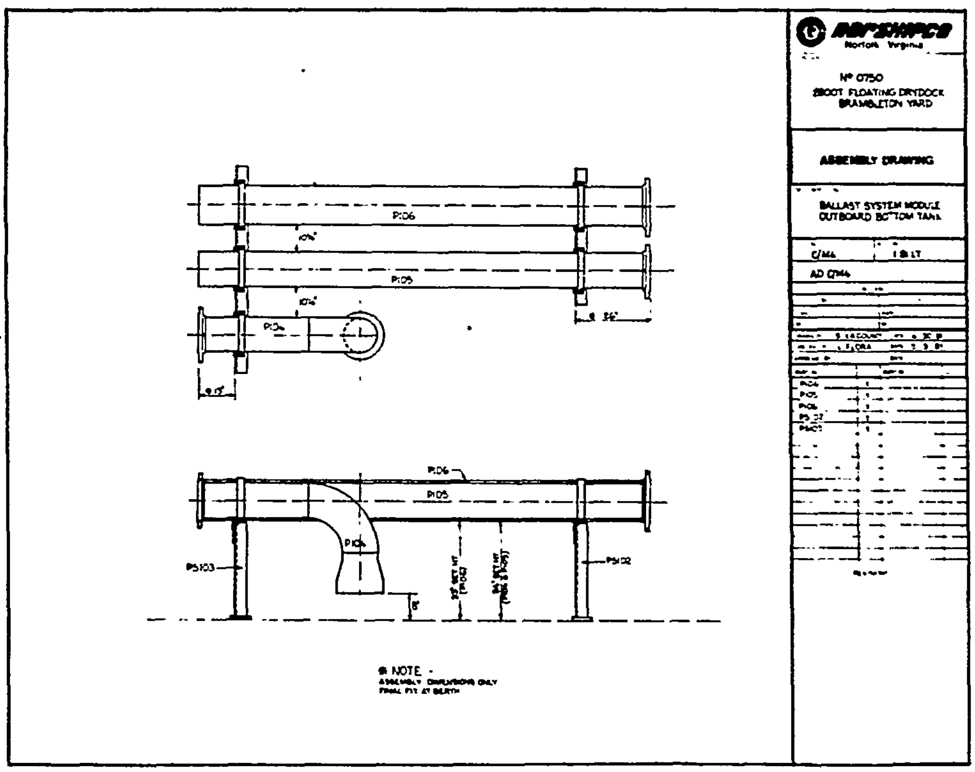
FIGURE 10





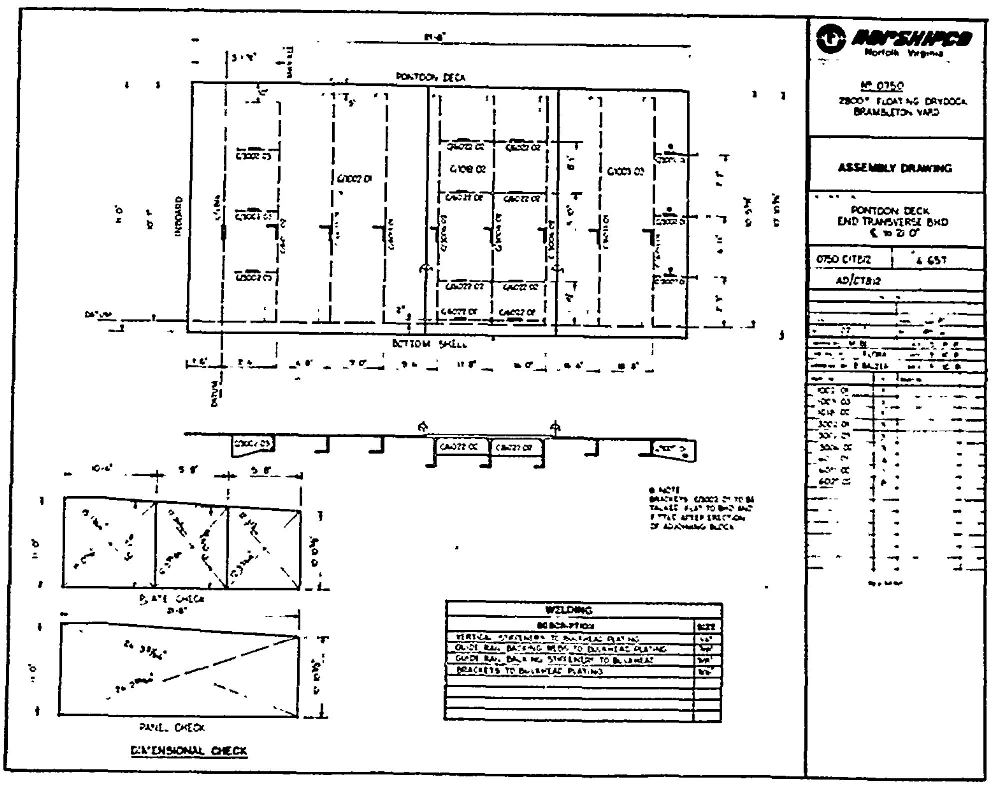

TRANSVERSE WEB ASSEMBLY DRAWING

FIGURE 11



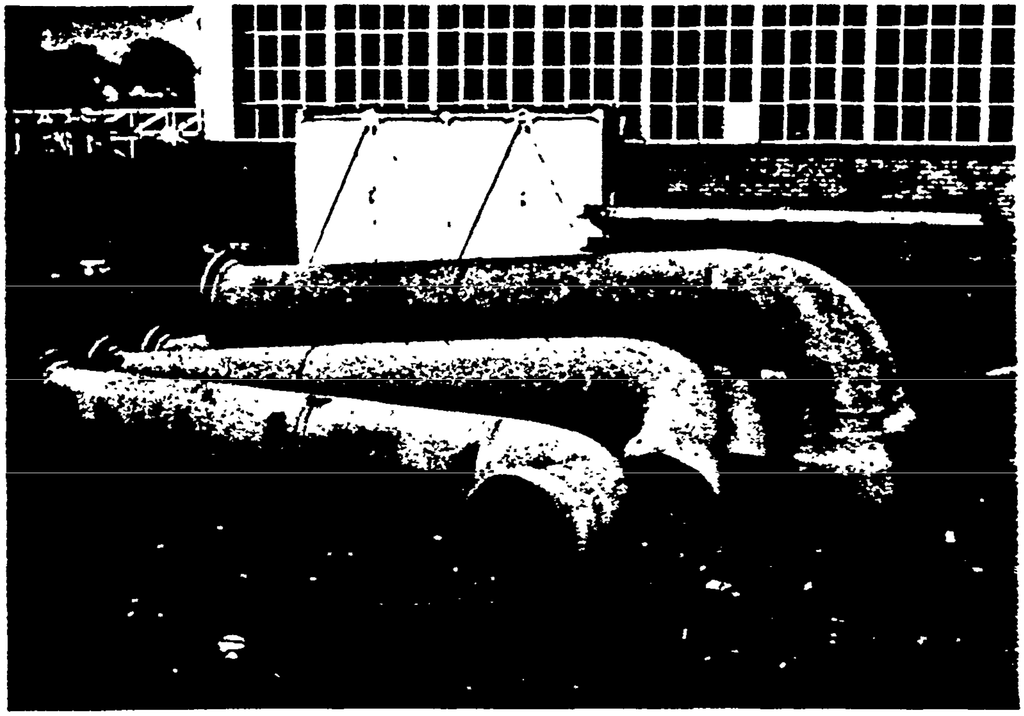

PIPE MODULE ASSEMBLY DRAWING

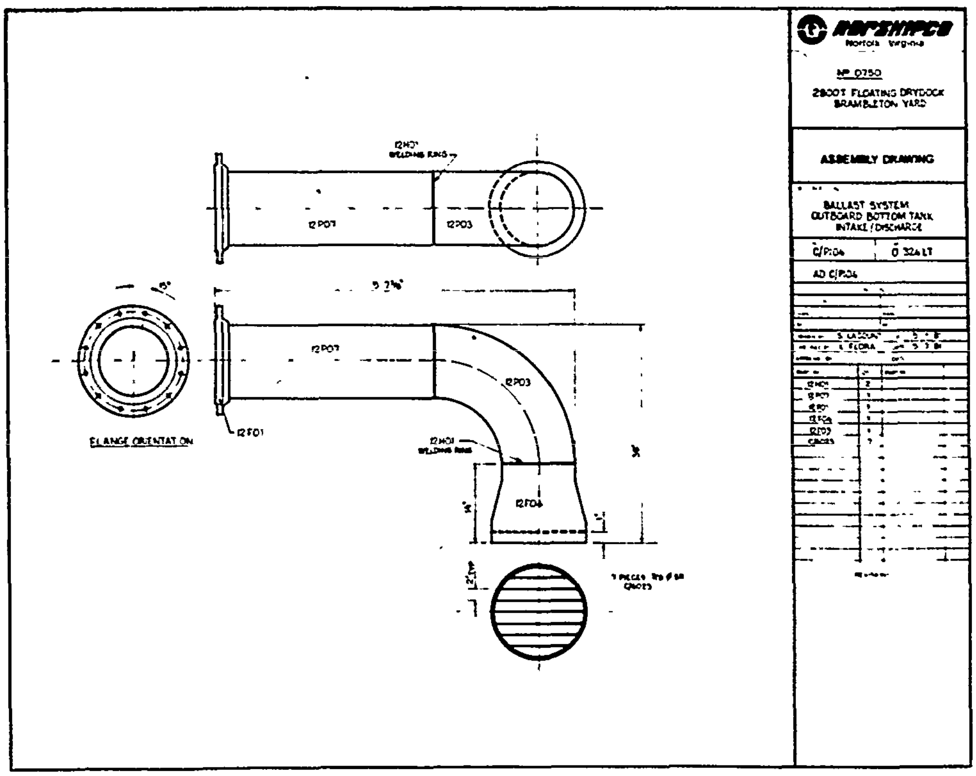
FIGURE 12




TRANSVERSE BULKHEAD ASSEMBLY DRAWING

FIGURE 13






PIPE ASSEMBLY DRAWING

FIGURE 14

| | **PLATE CUTTING CM-80** | Contract 0750 | Structure Group F |
|---|---|---|---|
| NORSHIPCO | | Prepared By Y. B. MILLER | Date 5·8·81 |
| | | Revision | Date |

Plate Material Information

| Plate Mark | [illegible] | [illegible] | No. of Pieces | Plates This Operation |
|---|---|---|---|---|
| 0750 F 3003 | 19 | F 3003 | 152 | 7 |

Raw Plate

| [illegible] | Length | Breadth | [illegible] |
|---|---|---|---|
| 3003 | 266 | 113 | 15·3 |

Used Plate

| Length | Breadth | Thickness | [illegible] |
|---|---|---|---|
| | | | |

Start / Finish relative to Datum Reference

| [illegible] | [illegible] | [illegible] | [illegible] |
|---|---|---|---|
| ½" | ½" | | |

Cutting Information

| CONTOUR PART | SPEED | TRAVEL | TIME |
|---|---|---|---|
| Marking | | | |
| Cutting | | | |
| Preheats | | | |
| Loading | | | |
| Unloading | | | |
| TOTAL OPERATION TIME | | | |

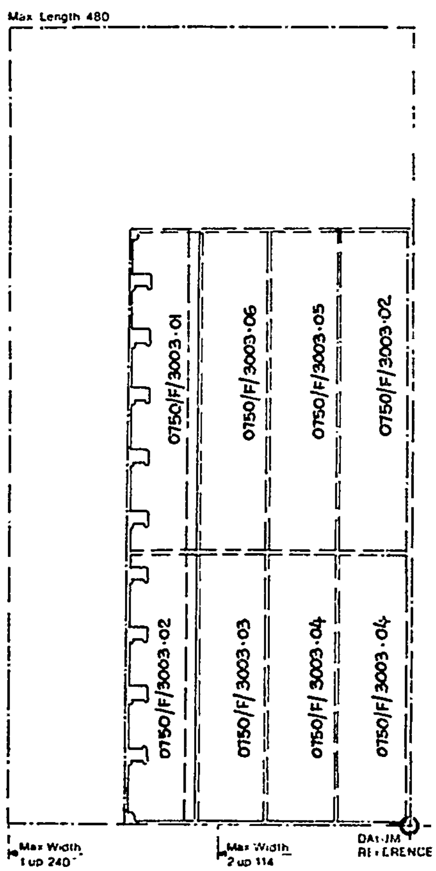
Square Cut Plate

| | [illegible] | [illegible] | [illegible] |
|---|---|---|---|
| Length | | | |
| Breadth | | | |
| [illegible] | | | |

Plate Arrangement & Cutting torch Allocation

| |
|---|
| Bevel Head |
| No 1 Slave |
| Bevel Head |
| No 2 Slave |
| Master Head |

| Operating Mod | Component | Mirror |
|---|---|---|




CUTTING ARRANGEMENT 3/16" = 1'-0"

FIGURE 15 PIECE PART INFORMATION

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